

Aviation Safety Program

System-Wide Accident Prevention

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National Research Council

Washington D.C.

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Outline

Aviation Safety Program

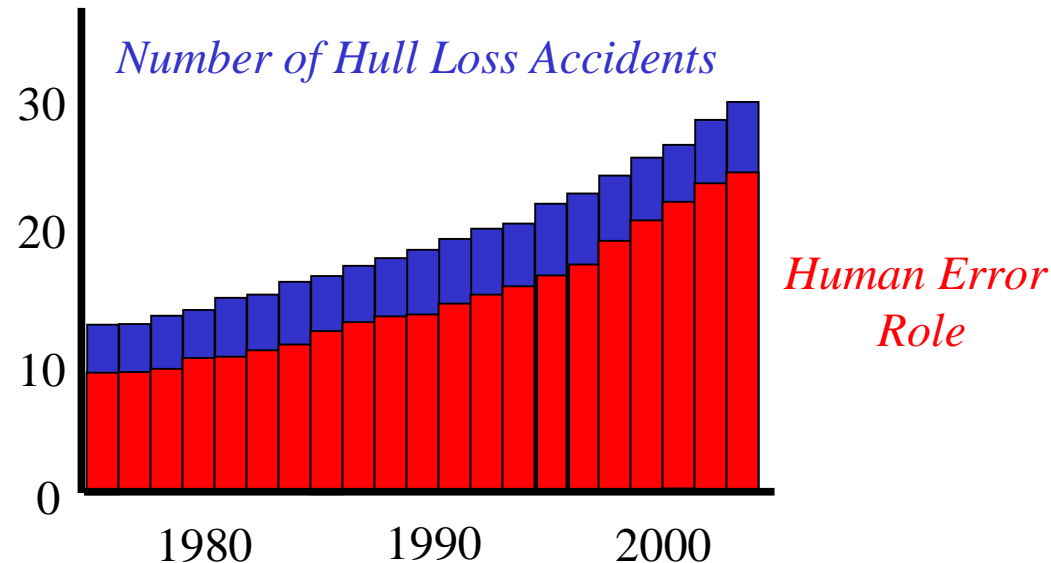
SWAP

Human error in aviation	3
SWAP Goal	4
Active SWAP Partners	5
SWAP Approach	6
SWAP Milestones	7
Current SWAP Project Organization	8
SWAP Element Products	
HPM	11
MHF	12
Training	13
PHF Background	14
PHF	15

Human Error Role in Aviation Accidents

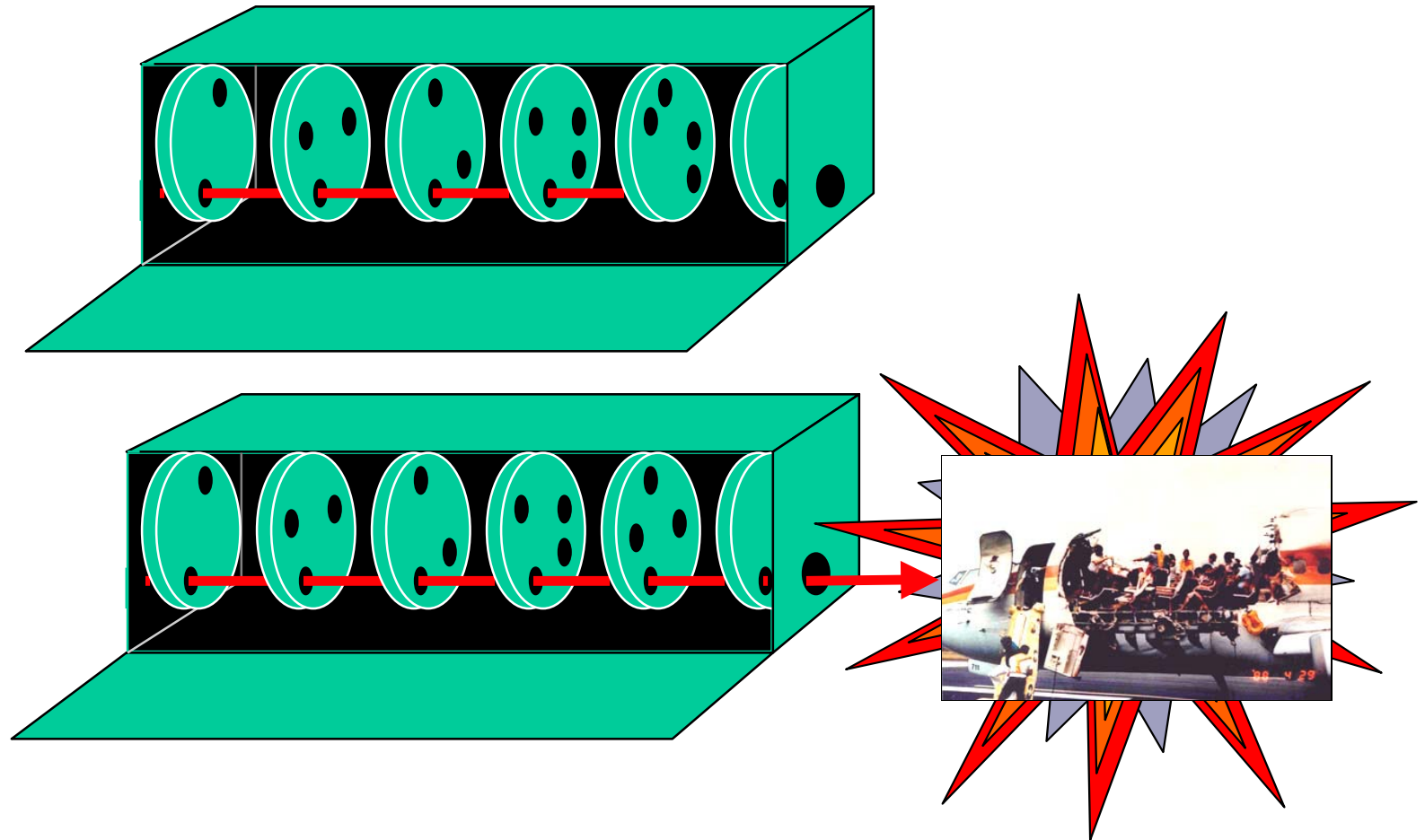
Aviation Safety Program

SWAP



- Number of hull loss accidents has steadily increased over the past 25 years
- Human factors issues have steadily accounted for ~70% of these accidents
- Introduction of new technological devices or procedures
- Trading one source of human error for another

SWAP uses current knowledge about human cognition to develop mitigation strategies to address current trends in accident and incident profiles

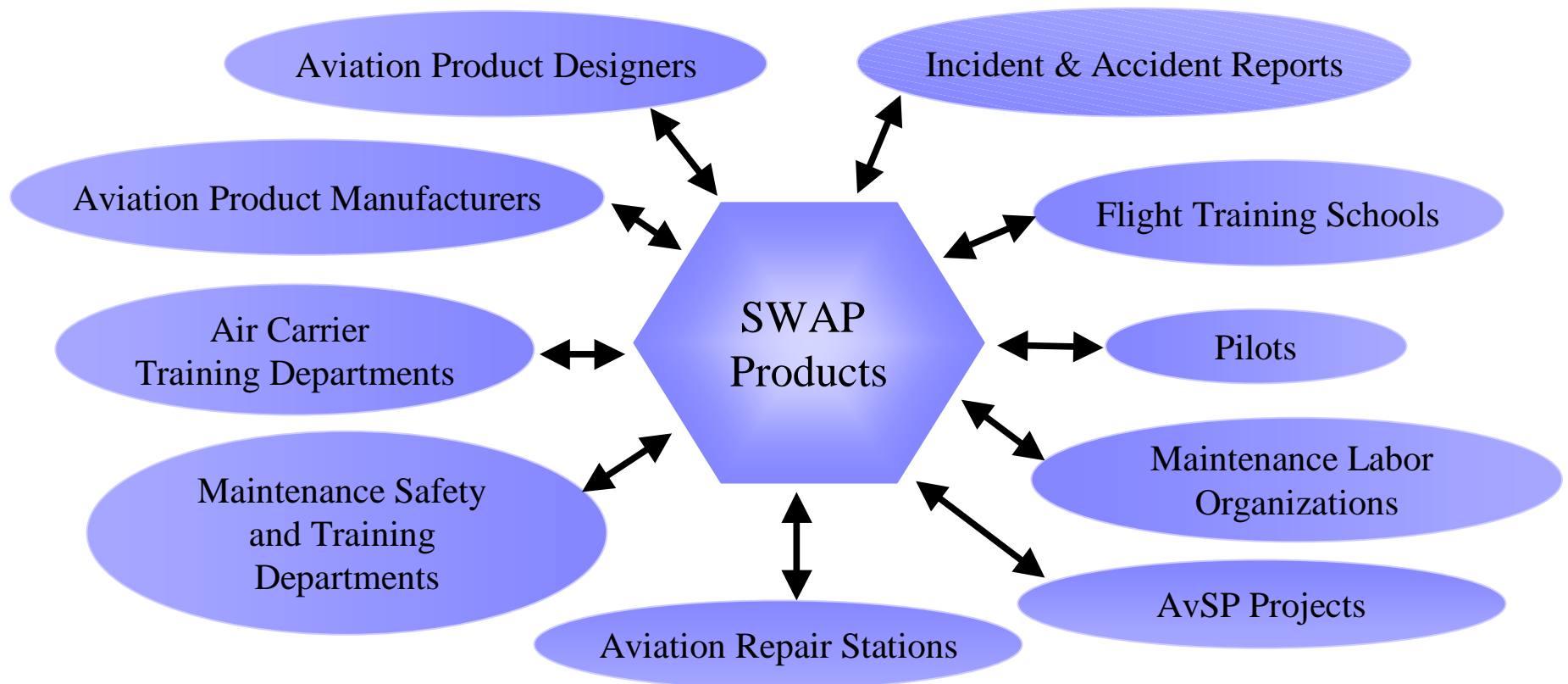


- Accidents result from a chain of events
- Many distinct human error related causes of aviation accidents, due to behavior of both air and ground crew
- Degree that each of these precursors contributes to accidents varies over time

Active SWAP Participants

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SWAP



Identify user requirements up-front

- helps with user acceptance
- establishes a clear transition path to industry implementation

Approach

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Accident & Incident Analysis



ASRS

Aviation
Research

Literature
Reviews



•Consult with subject matter experts

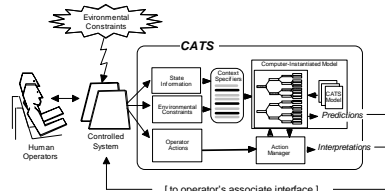


•Scientists are rated pilots

**Field Tests
(Flight tests)**



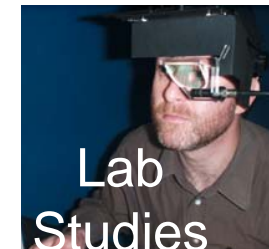
**Part-task
& Full Mission
Simulations**



**Computational
Modeling**






























































**Field
Observation
Data**



**Lab
Studies**

AvSP/SWAP Program & Project Milestones

	2000				2001				2002				2003				2004				2005			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Program	Preliminary Integrated Program Assessment 				 Safety-Improvement Concepts Defined				Interim Integrated Program Assessment 				 Simulation & Flight Test Evaluations of Safety Improvement Systems within AvSP Complete				Integrated Program Assessment 				Integrated Full-Mission Apps. Simulations & Validation 			
2.2 System-Wide Accident Prevention	 CD-ROM Icing Training Module				 Proficiency Standards				Model High Error Probability Contexts and Solutions 				Procedure Training Modules  Cross-Cut Hum. Factor Res.  Integrated CATS Mod of FMS  Avn Info Mgmt 				Aug Reality Displays Eval.  Prototype Training Modules  MRM Guidance Revise Comp. Mod 							
2.2.1 Human Performance Modeling					ID High Error Probability  ID Modeling Tools  Dev. Intent-inference Models 				ID Data for Sim  Error Sim w/ CATS  Demo CATS  Cognitive Models 								Advanced Cogn. Models  Catalog/Class Errors 							
2.2.2 Maintenance Human Factors	 MRM Skills Defined Augmented-Reality Prototype 								 Task/Risk Analysis Software V-R Sim Prototype 				T/R Analysis Software Demo 				 Collaborative Engineering Tool MRM Guidance & Tools 							
					Prototype Training Materials 				Develop Procedure Improvements  Estab. Current Baseline 				 Commo Problem Solving MRM Cross-Team Skills Defined  T/R Analysis Tools 											
2.2.3 Training	 Prototype Helicopter				Alert Mgmt Training Models  Accident 				Pilot Wx Decision Guidelines  Automation Training  Low Blood Sugar Perform.  Guidelines for Trng  Icing Encounter Flt Trng 				 Wx Condition Effects  ASRS & NTSB Analysis  Promote Cockpit Automation 				Emerg/Abnorm Sit Rev.  Declaring Emerg.  Aircraft Icing Sim 							
2.2.4 Program Human Factors					Aviation Display Intuitiveness  Cross-Cutting Human Factors 				 Bibliography of Human Performance Research Alerting System Integration 				 AvSP Assess/Recommnd Documentation of HF Tools 											



- Level I Milestone



- Level II Milestone



- Level III Milestone



- Level II Milestone Roll-up

Blue – Roll-up to Level I #2

Red – Roll-up to Level I #4

Green – Roll-up to Level I #5

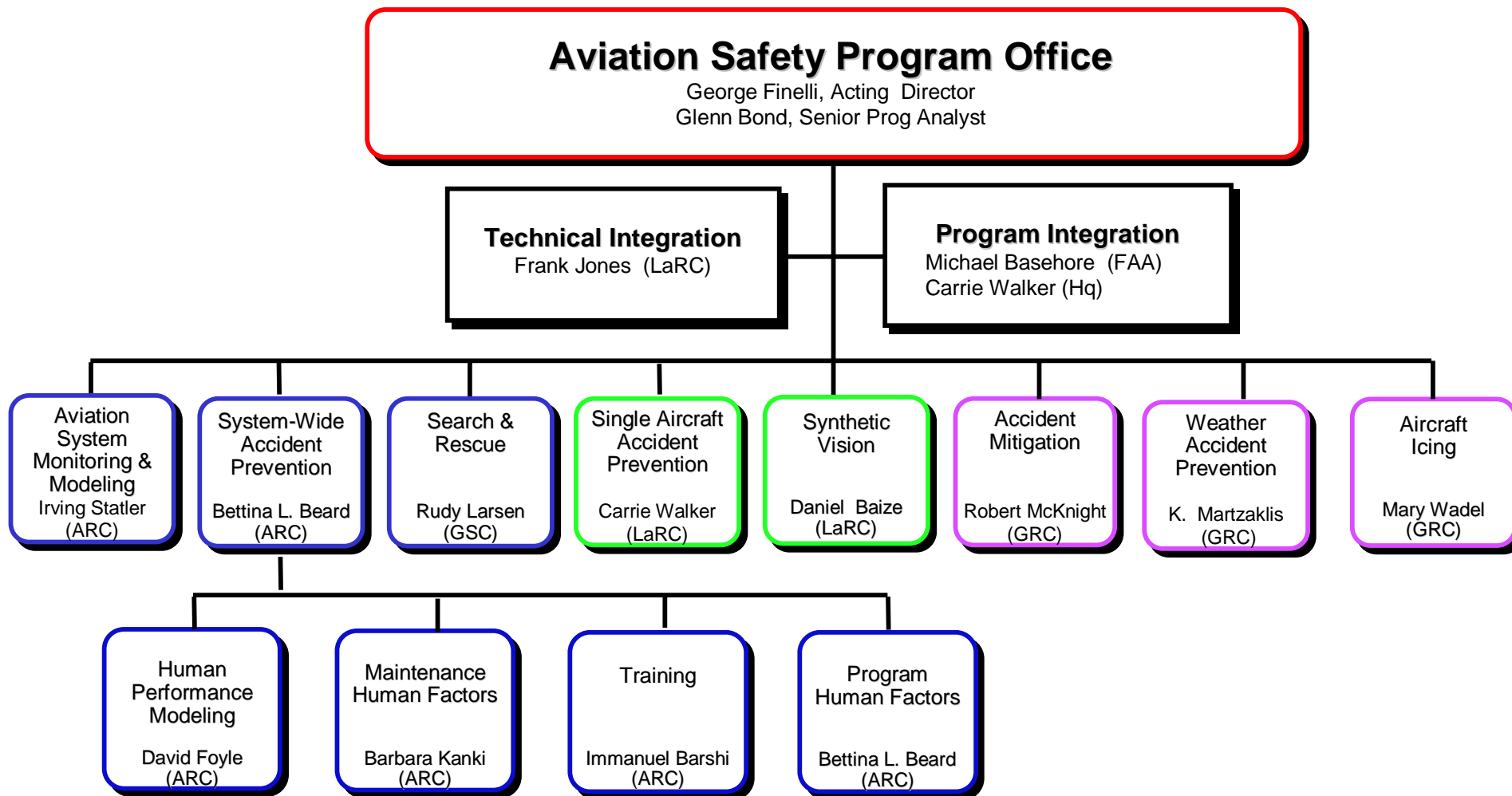
Brown – Roll-up to Level I #7

Orange – Contingency Milestone

Current AvSP Program Organization

Aviation Safety Program

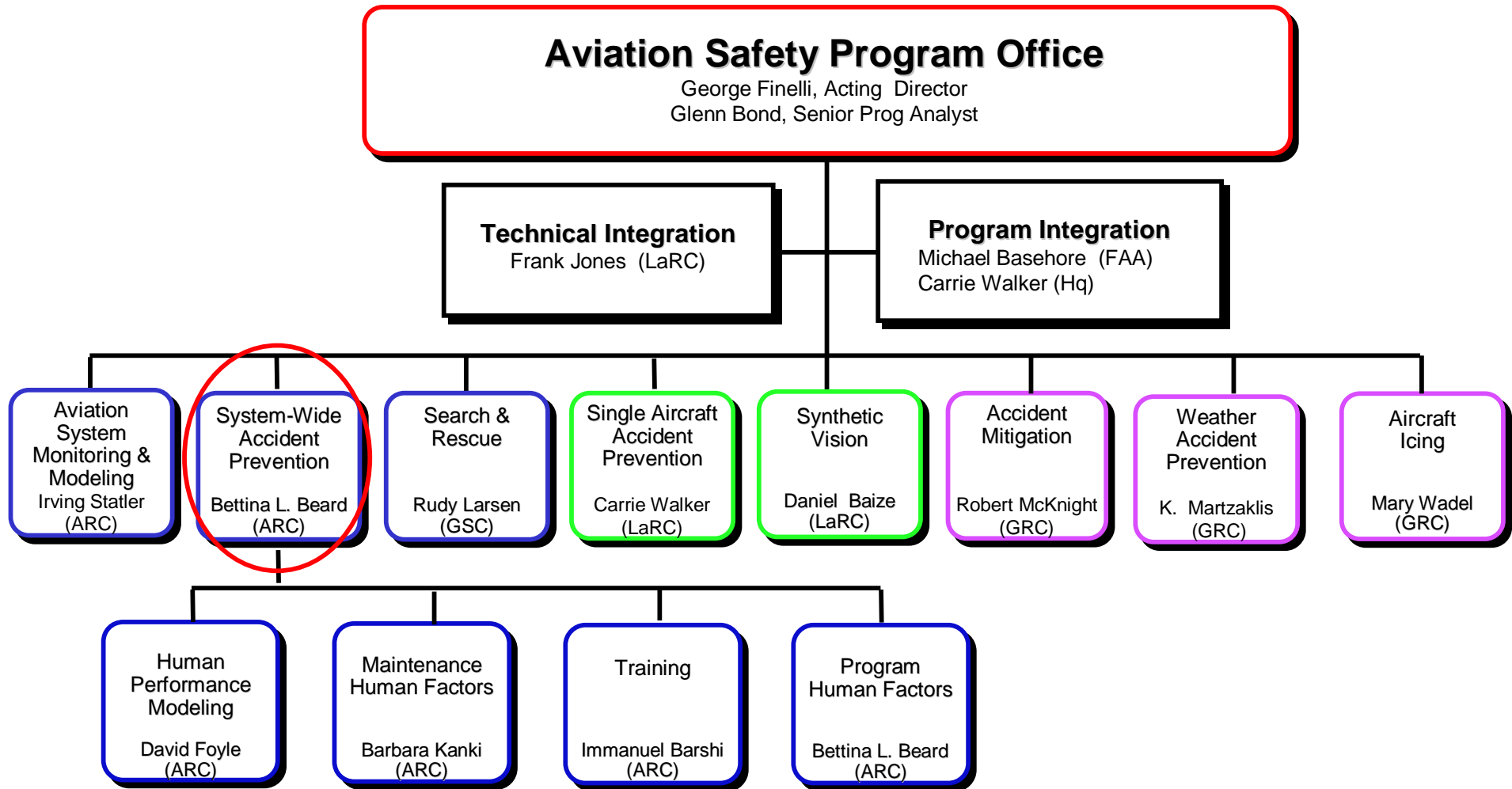
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Current AvSP Program Organization

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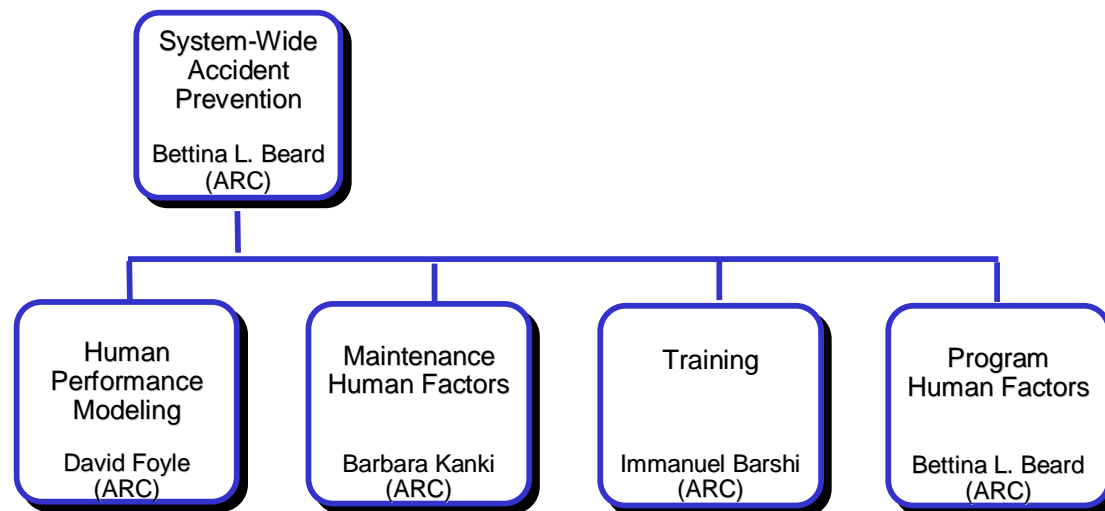
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SWAP Project

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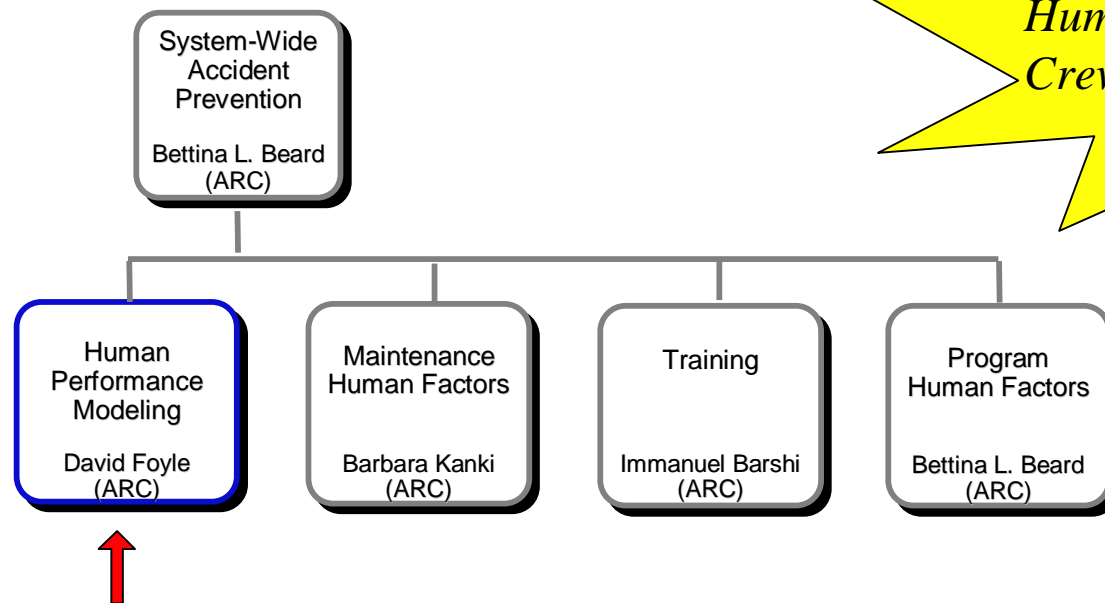
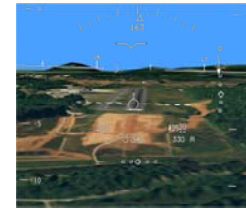
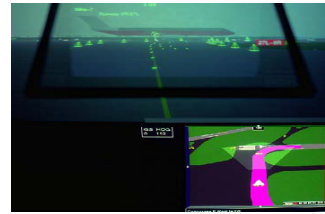
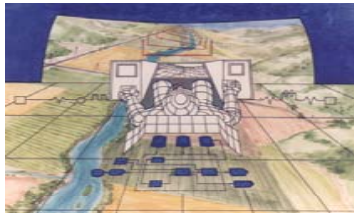
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HPM Products

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*Human Performance Models
Crew Activity Tracking*

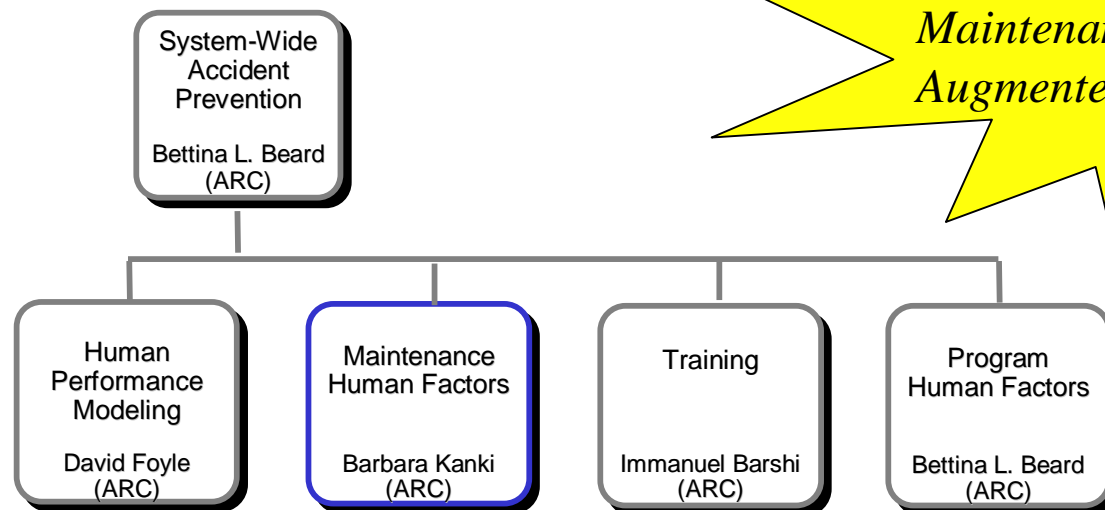
MHF Products

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Maintenance Risk & Task Analysis Tools
Maintenance Resource Management (MRM)
Augmented/Virtual Reality Displays



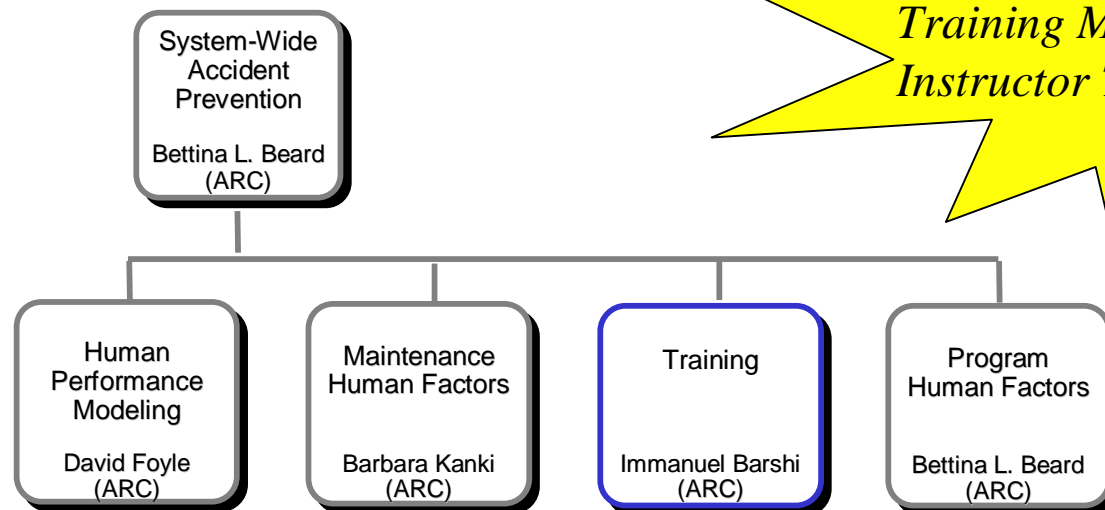
Training Products

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*Pilot Skill Training for Cockpit Automation
Training Modules and Simulators
Instructor Training & Evaluation*



Taken from Report of the IAR, June 8, 2000

Watch Item - Human Factors Engineering

- *Human factors engineering not fully integrated within some technology product plans*
 - synthetic vision systems
 - weather accident prevention

Recommendation:

- formal human factors engineering should be accomplished for appropriate products from the very beginning of product design

Proposed AvSP Perform a Behavioral Risk Assessment, July 17, 2000

1. properly address human factors issues
2. limited budget - need assessment as to the importance of particular human factors issues as guidance to the system designer
3. include the human in 7120.5A program requirements
4. respond to IAR watch item

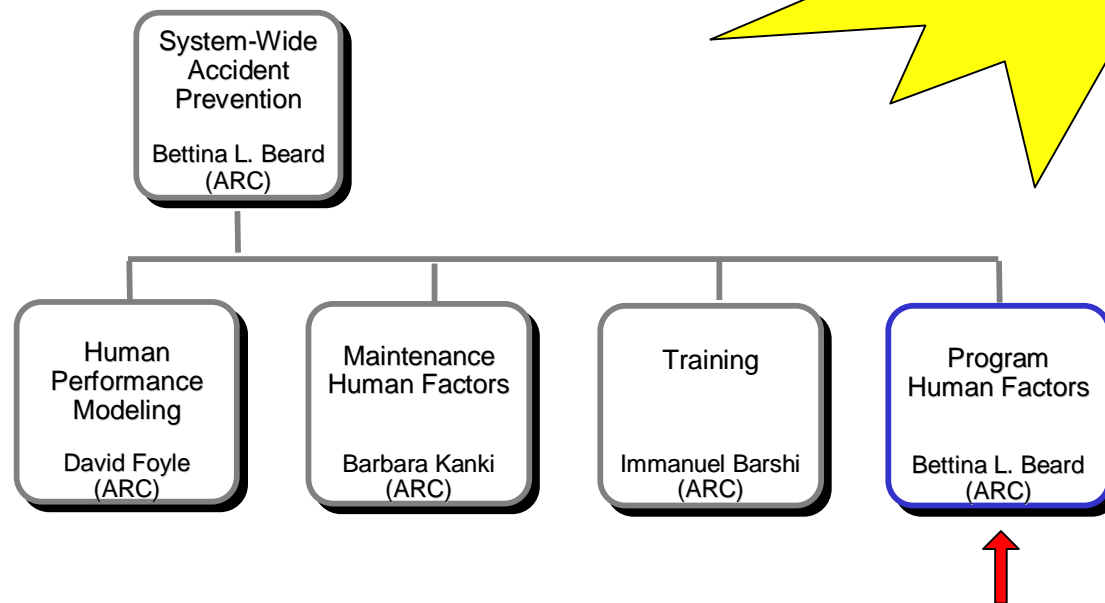
PHF Products

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Human Factors Tools



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System-Wide Accident Prevention

Dr. Tina Beard

Program Human Factors Element

Outline

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SWAP

PHF Goal	18
PHF Products	
Crew Centered ConOps	19
SvS Searchable Bibliography	20
Display Intuitiveness Metric	21
SvS & WxAP HF Issues Document TOC	22
SvS HF Issues Checklist	23
WxAP HF Issues Checklist	24
Alert & Warning Integration	25-26

The PHF Goal

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Assess cross-cutting human factors issues and provide expertise and recommendations toward the individual Project's human factors initiative.

Potential advantages:

- ID human factors issues that are stimulated by the new system
- provide Program with human factors priorities
- provide information about vulnerable aspects of product requiring further refinement
- address key integration issues of Program products into cockpit

Program
Human
Factors
Tina. Beard
(ARC)

PHF Crew Centered Con Ops

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- Many AvSP technologies impact cockpit.
- The crew position is the unifying viewpoint for the benefit of AvSP Program as a whole.
- Notional description of cockpit equipment and procedures from crew viewpoint that assumes presence of technical products of AvSP
- Other developments that will influence character of cockpit and procedures identified.
- Baseline flight task description completed
- Explicit descriptions and scenario showing future character of cockpit and procedures for AvSP technologies.

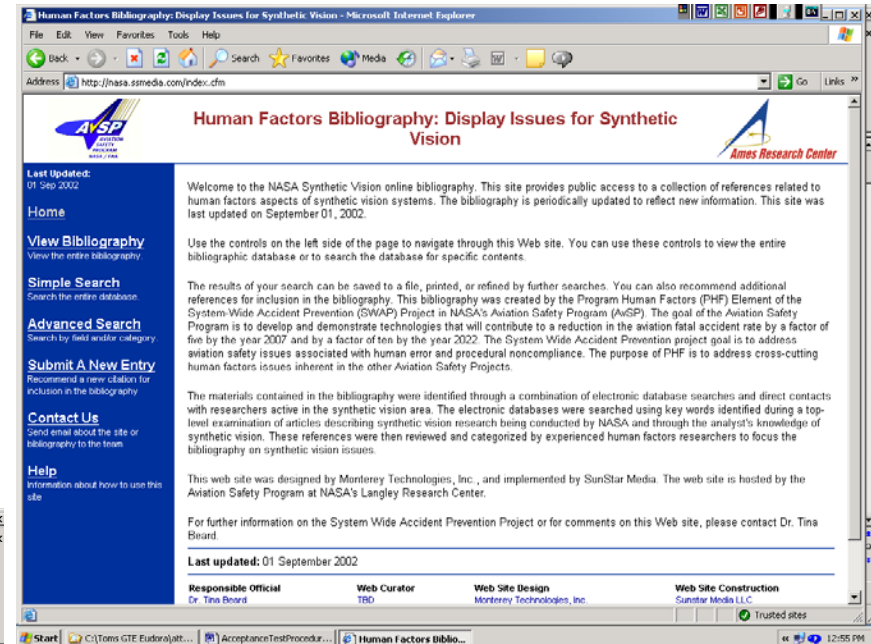
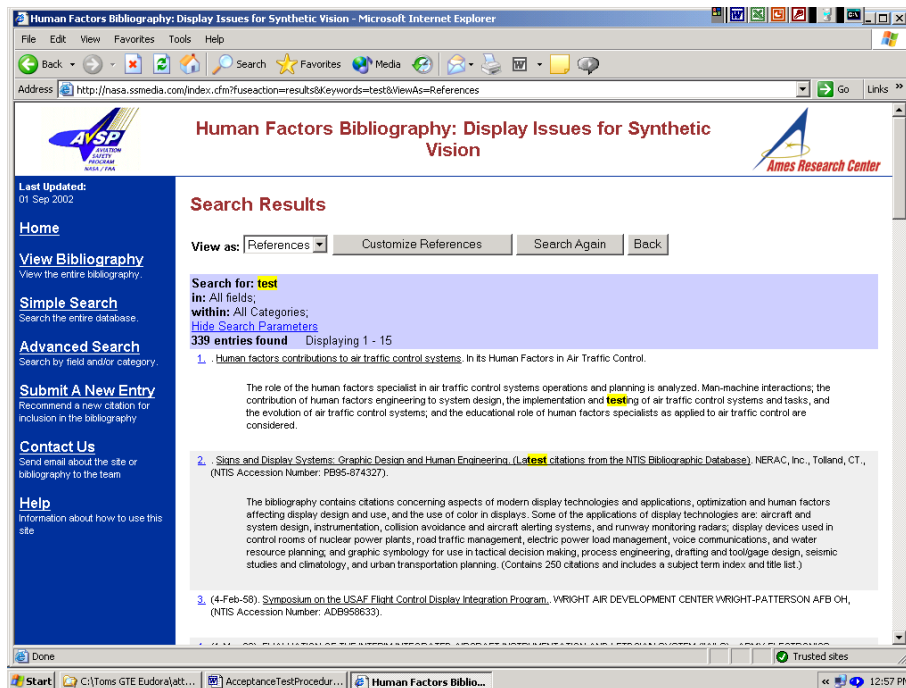
https://postdoc.arc.nasa.gov/postdoc/t/folder/main.ehtml?url_id=82510

poc: Dr. Robert Hennessy
Monterey Technologies Inc.

SVS Displays Human Factors Website

The website allows the user to:

- View all citations in the bibliography
- Perform simple or advanced searches
- Extract to file or print results
- Submit citations for inclusion
- Contact the curator



Features:

- Multiple Search Criteria
- Keyword search
- Variety of formats for results
- Tailorable formats
- Built in online help

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PHF Aviation Display Intuitiveness

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Metrics for Display Intuitiveness Assessment (MeDIA)

To quickly assess whether a new display is intuitive

Primary measures:

- Presenting the information saliently
- Supporting completeness of information for task performance
- Presenting the stimuli so that it may be rapidly (re-)learned
- Minimizing the information translation required
- Supporting a high amount of information transfer
- Supporting the rapid comprehension of state transitions
- Presenting future state information

MeDIA development involves collection of part-task sim data



poc: Dr. Robert Hennessy
Monterey Technologies Inc.

PHF HF Issues Documents & Prioritization

Aviation Safety Program

SWAP

Table of Contents

1.	Introduction	3
2.	Background	4
2.1.	Image Quality	4
2.1.1.	Head-Up Display (HUD)	4
2.1.1.1.	Field of View (FOV) / Display size	4
2.1.1.2.	Clutter	5
2.1.1.3.	Iconography	5
2.1.1.4.	Resolution	5
2.1.2.	Head-Down Display (HDD)	5
2.1.2.1.	FOV	5
2.1.2.2.	Iconography	5
2.1.2.3.	Resolution	6
2.2.	Information Integration	6
2.2.1.	Guidance	6
2.2.1.1.	Pathway-in-the-sky / highway-in-the-sky	6
2.2.1.2.	Symbolology	7
2.2.1.2.1.	Predictor / Velocity Vector symbol	7
2.2.1.2.2.	Follow Me Airplane (FMA) or aircraft trend performance prediction	7
2.2.1.3.	Terrain depiction	7
2.2.2.	Terrain avoidance / altitude judgments	8
2.2.3.	HUD vs. HDD	8
2.3.	Operational concepts	9
2.3.1.	Transitions	9
2.3.2.	Crew interaction	9
2.3.3.	Display interaction	9
2.3.4.	Resource management	9
2.3.5.	Crew confidence	10
2.3.6.	Off-nominal events	11
3.	Research recommendations	12
3.1.	Image Quality	12
3.1.1.	FOV / Display size	12
3.1.2.	Clutter	12
3.1.2.2.	Amount of non-iconic information	12
3.1.3.	Iconography	12
3.1.3.1.	Size	12
3.1.3.2.	Color	12
3.1.3.3.	Visual momentum	12
3.1.4.	Resolution	12
3.1.5.	Contrast	12
3.1.6.	Opacity	12
3.1.7.	Effect of fog/clouds/weather	12
3.2.	Information Integration	13
3.2.1.	Guidance	13
3.2.1.1.	Tunnel-in-the-sky vs. follow-me-aircraft	13
3.2.1.2.	Tunnel-in-the-sky and predictor vector	13
3.2.1.3.	Follow-me-aircraft and predictor vector	13
3.2.1.4.	Coplanar view	13
3.2.2.	Terrain avoidance / altitude judgments	13
3.2.2.1.	Photo realistic terrain vs. wire frame	13
3.2.2.2.	Crew confidence	13
3.2.2.3.	Altitude errors	13
3.2.2.4.	Cognitive tunneling	13
3.2.2.5.	Integration w/ Terrain and Collision Avoidance Sys. (TCAS, and HDD)?	13
3.2.2.6.	Trend information	13
3.2.2.7.	Equipment integration / cognitive tunneling	13
3.2.2.8.	Actual increase or decrease in real workload?	13
3.3.	Operational concepts	14
3.3.1.	Transitions between phases of flight	14
3.3.2.	Crew interaction	14
3.3.3.	Failure or potential failure of SVS	14
3.3.4.	Essential information	14
3.3.5.	Effect at various workloads	14
3.3.6.	Crew confidence in system	14
3.3.7.	Resource management	14

TOC

SvS

AWIN

1.	Glossary of Terms/ Acronyms	ii
2.	Introduction	1
3.	Background	1
4.	Weather Factors Affecting Flight	2
4.1.	Moisture	3
4.2.	Temperature	3
4.3.	Movement	3
4.4.	Volcanic Ash and Lightning	3
5.	Weather Information Availability in the Cockpit	3
5.1.	Weather Display Systems	4
5.1.1.	Alerting and Notification of Conditions Outside the Aircraft (ANCOA)	4
5.1.2.	Graphical Weather Information System (GWIS)	5
5.1.3.	Aviation Weather Data Visualization Environment (AWE)	6
5.1.4.	Corridor Integrated Weather System (CWIS)	7
5.1.5.	Airborne Hazard Awareness System (AHAS)/ AWARE	8
5.2.	Sensors	9
6.	Issues Affecting Weather Information Availability in the Cockpit	10
6.1.	Information to Present in Different Phases of Flight	10
6.2.	Types of Flight	12
6.3.	Weather Information Update Rate	12
6.4.	Integration Issues	13
6.4.1.	Integrated vs. Separated Displays	14
6.5.	Display Presentation Formats	14
6.5.1.	View Perspective (Coplanar vs. Monoplane, 2D vs. 3D)	14
6.5.2.	Presentation of Traffic, Terrain and Weather	15
6.5.3.	Graphical vs. Text Based Information	16
6.5.4.	Display Symbols	17
6.5.5.	Alerts	20
6.5.5.1.	Levels of Categories	20
6.5.5.2.	Auditory Alerts	20
6.5.5.3.	Visual Alerts	21
6.5.6.	Map Orientation	23
6.6.	Display Conceptual Information	23
6.6.1.	Trends	23
6.6.2.	Status vs. Command Displays	23
6.6.3.	On-demand vs. Background Update	24
6.7.	Display Characteristics	25
6.7.1.	Size and Legibility	25
6.7.2.	Menu Navigation	25
6.7.3.	Range and Granularity	25
6.8.	Decision Aids	26
6.8.1.	What and How to Aid	26
6.8.2.	Training	27
6.9.	Failed Mode Operations	28
6.9.1.	Loss of Service/ Communications	28
6.9.2.	Partial Degradation	28
6.10.	Market Research	29
6.10.1.	Cost Issues	29
6.10.2.	Experimental Methodology	30
6.11.	Operational Concepts	30
7.	References	31

PHF HF Issues Document & Prioritization

Aviation Safety Program

SWAP

Human
Factors
Issues

SvS
Concerns

		Predictor or Velocity Vector	Photorealistic Terrain	Wireframe terrain	Egocentric 3-D View
Workload					
	Mental demand	Ref: 1.2.1.1 Predictor workload not as high as FMA	Ref. 1.1.5.3 terrain provided spatial awareness - 1.1.7.2 Terrain improved SA, not performance - 1.1.8.4 Terrain slope perception - 1.1.5.4 Landing flare strategies	Ref. 1.1.5.3 terrain provided spatial awareness - 1.1.7.2 Terrain improved SA, not performance - 1.1.8.4 Terrain slope perception - 1.1.5.4 Landing flare strategies	Ref: 1.1.1.1 Low cognitive integration - 1.1.8.5 High mental proximity - 1.1.5.4 Flare strategy
	Physical demand	N/A	Ref: Long delays & sickness 1.1.2.2	Ref: 1.1.2.2 Long delays & sickness	Ref: 1.1.1.1 No cost of visual scanning
	Temporal demand	Ref: 1.2.1.1 Predictor workload not as high as FMA	Not tested	Not tested	Ref: 1.1.1.1 Low cognitive integration cost, but keyhole effect - 1.2.3.2 Few visual cues for distance to tunnel - 1.1.5.4 Flare strategy
	Performance	Ref: 1.2.1.1 Predictor not as accurate as FMA - 1.1.5.3 altitude judgement	Ref: 1.1.7.2 Terrain improved SA, not performance - 1.1.5.4 Landing flare - 1.1.5.2 Telepresence and performance - 1.1.5.3 Improved altitude judgements	Ref: 1.1.7.2 Terrain improved SA, not performance - 1.1.5.4 Landing flare - 1.1.5.2 Telepresence and performance - 1.1.5.3 Improved altitude judgements - 1.1.5.4 Perception & Density	Ref: 1.2.1.1 pathway acquisition accuracy - 1.1.1.1 Better orientation than distance judgements
Situation Awareness					
	current situation ownship systems	Not tested	Not tested	Not tested	Ref: 1.2.3.2 Better trend tracking needed
	current situation-geographic				Ref: 1.1.1.1 Depth ambiguity, better orientation judgements - 1.1.5.1 Reduced global SA - 1.2.3.3 Improved SA, representative of terrain outside
	current situation-environmental	Ref: 1.1.6.3 Guidance symbology - 1.2.3.3 SA improved	Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare	Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare	Ref: 1.2.3.2 Task complexity more powerful on ability to focus outside of cockpit than display OS novelty - 1.2.3.3 Relative position SA improved
	current situation-spatial/temporal				Ref: 1.2.3.2, 1.2.3.3 Good spatial awareness, Awareness of secondary info on display questionable, Most wanted 2-D Nav + 3-D tunnel display
	Projection/prediction	Ref: 1.2.3.6 Rejoining pathway - 1.1.6.3 Guidance symbology	Ref: 1.2.3.6 Projection improved - 1.1.7.2 Terrain improved SA, but not performance	Ref: 1.2.3.6 Projection improved - 1.1.7.2 Terrain improved SA, but not performance	Ref: 1.2.3.3, 1.2.3.6 Rejoining pathway
Appropriate Feedback					
	Operating Feedback	Ref: 1.1.6.3 direction indication & preview - 1.2.6.2 current nav error	Ref: 1.1.5.1 Terrain improves global SA - 1.1.5.4 Landing flare strategies	Ref: 1.1.5.1 Terrain improves global SA - 1.1.5.4 Landing flare strategies	Ref: 1.1.1.1 Keyhole effect, visual momentum w/ OTW - 1.1.5.1 Reduced global SA
	Modal Feedback for Operating	Visual	Visual	Visual	Visual
	Failed Mode Feedback	Nothing currently exists	Nothing currently exists	Nothing currently exists	Nothing currently exists
	Alerts				
	number levels of meaning modalities used	Nothing currently exists	Nothing currently exists for a single SVS display	Nothing currently exists for a single SVS display	Nothing currently exists

PHF HF Issues Document & Prioritization

Aviation Safety Program

SWAP

Human
Factors
Issues

WxAP
Concerns

		AWARE	GWIS	AWE	ANCOA	Other Studies
		Aviation Weather Analysis and Reporting Enhancements	Graphical Wx Information System	Aviation Wx data visualization Environment	Alerting and Notification of Conditions Outside the Aircraft	
		Ruokangas -NASA& Rockwell Collins	Scanlon -NASA	Spirkovska & Lodha- NASA	Ververs, Dornreich, Good, Rye, Downs, Niehus, & Dewing - Honeywell	
Workload						
Mental Demand			6.5.3 Wx monitoring should be automated, provide indication according to their importance.		6.3.1 Separate display had a higher workload than an integrated display.	6.6.2 status displays may be preferable to command displays as they yield more robust performance benefits and appear less vulnerable to automation biases
			6.5.6. Provide automatic reorientation or interface control to point the aircraft symbol up allowing the pilot to change to a track up position when showing information.		6.5.3 Pilots may not know when/what to request for wx information.	
					6.4.2 Integration display increased time to react than with a separate display.	
Physical Demand			6.6.2 Excessive menu navigation frustrate pilots.			
Temporal Demand						
Performance	Performance increased compared to DUATs		6.5.1 Reduced reliance on ground based wx sources.		6.3.1 Performance increased with a single alert without having to mentally integrate	6.5.1 Not all pilots know the value of getting wx trend information. 6.5.2 Less reliance on automation, with status displays than command displays.
Situation Awareness						
current situation ownship systems			6.5.1 Subject didn't understand location of wx relative to position of aircraft.	6.8.2 Wanted a visual reference of what airport is being reported.		6.8.2 Pilot had trouble identifying location of aircraft without an ownship icon. SA increased with ownship icon
current situation-geographic			6.4.6 Map orientation should be track up configuration otherwise, mental rotation	6.4.2 VFR chart background easily helps identify where they are.		6.4.2 SA increased when spatially related databases on integrated display. 6.5.3 Display should alert pilot that situation has changed.
current situation of weather			6.5.1 Trend information and location of wx increased SA			6.5.1 Provided wx trends to improve SA
current situation n- spatial/temporal						6.4.5 Info on spatial location is more important than severity of hazard.
Projection/ Forecasting				6.5.1 Automatic TAF didn't show forecast for all airports/timeframe only. Selected airport based on arrive time		6.7.1 Lack of SA due to lack of experience and general wx conditions. 6.2 Verbal and written reports of weather conditions are simply not sensitive enough to discriminate between differences that exist across experience levels
Appropriate Feedback						
Operating Feedback				Provides alternative route selection.		
Modal Feedback for Operating	Visual			Visual	6.4.5.2 Time critical - Synthetic voice. Tactical & strategic earcon.	

Alert & Warning Integration

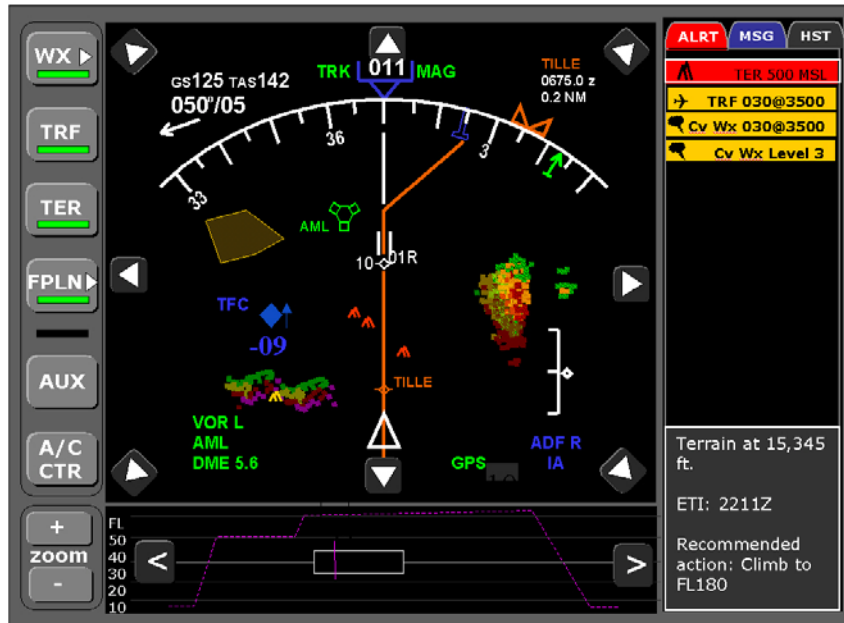
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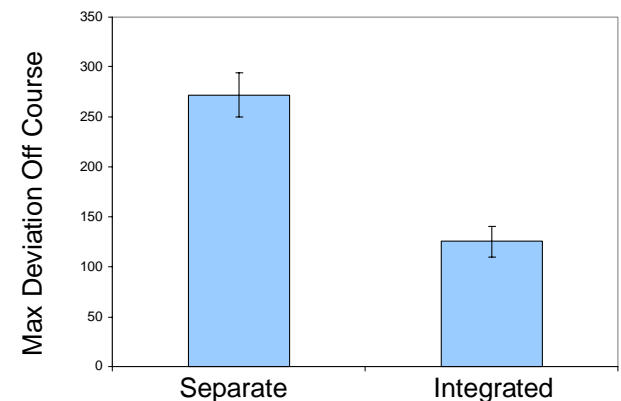
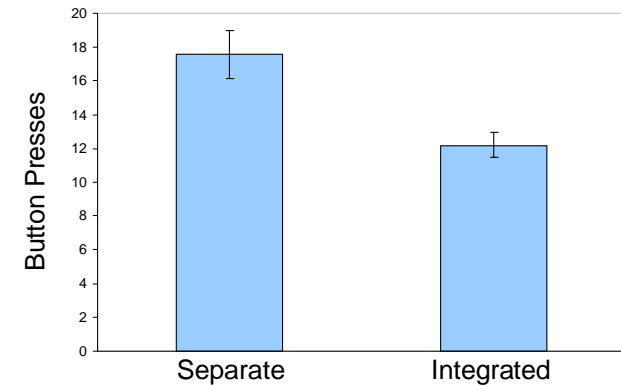
- There is a proliferation of alerting on the flight deck. Current and new systems have separate alerts and notification philosophy for informing the crew.
- The ANCOA (Alerting and Notification of Conditions Outside the Aircraft) program has begun to look at these issues and has demonstrated the integration under a common framework.
- ANCOA provides guidance to how information gets filtered, categorized, prioritized, and represented to the crew.
- Recommend a clear alerting philosophy and notification scheme for the integration information, particularly terrain and weather.
- Generate design specifications
- Implement specifications in software
- Review integrated system with expert pilots

Terrain/Traffic/Wx Integration

Research Findings



Integrated Alerting System prototype indicating overlay of weather, terrain, and traffic on a single display



Data supports the integration of currently disparate systems onto a single display with performance requiring fewer pilot inputs and lower workload scores

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